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motions of the stars, based upon the slowly increasing knowledge of these motions given by measures of position.

The Dudley Observatory has been nominally connected with Union College, Schenectady, New York, as a special department, and the director of the observatory has held the rank of professor in that institution. The honorary degree of A. M. was conferred upon Professor Boss by Dartmouth in 1877, of LL.D. by Union in 1902, and of Sc. D. by Syracuse in 1910.

He received the gold medal of the Royal Astronomical Society in 1905, and the Lalande prize of the Paris Academy of Sciences in 1911. He was a member of the National Academy of Sciences and of the *Astronomische Gesellschaft*, a Foreign Associate of the Royal Astronomical Society, and a corresponding member of the British Association, the Prussian Academy, and of the St. Petersburg Academy.

His personal acquaintance with astronomers of all nations was extensive, and his friendship with those abroad was renewed by several European visits. Close affiliation with the most prominent men in this country was kept up at the meetings of the National Academy of Sciences at Washington, which he very rarely failed to attend. His last appearance at those meetings will be recalled by his friends as his last active participation in general scientific affairs.

Professor Boss was married in 1871 to Miss HELEN HUTCHINSON of Washington. His widow, three daughters and a son, all of the children now married, have survived him, as members of a family circle that was always singularly devoted and united, in intimate contact daily with the origination, the development, and the execution of his many varied plans of work.

HENRI POINCARÉ.¹

HENRI POINCARÉ was born at Nancy on the 29th of April, 1854. His family was from Lorraine; his grandfather practiced pharmacy in Nancy; his father, in the same town, was a public-spirited doctor and an able lecturer on medicine; his

¹ From the obituary by LEBON in *Astronomische Nachrichten*, **192**, 335, 1912. Translated and abridged by J. H. PITMAN.

mother, understanding her duties admirably, assured the happiness and comfort of the home. The young HENRI POINCARÉ at the age of eight years was placed in the school in his native town. After he had distinguished himself as a literary and scientific student, he became, in 1873, a senior in the Ecole Polytechnique. Upon his graduation in 1875, he became a student of engineering in the upper national school of mines, and in April, 1879, he was appointed engineer of mines. In this office, POINCARÉ was marked by his respect for duty and his courage. While in the Bureau of Mines, of which he became Inspector-General in 1910, POINCARÉ entered the University of Caen on December 1, 1879, as assistant professor in the Faculty of Sciences. Less than two years later, October 21, 1881, he was called to the Faculty of Sciences of Paris. The lectures which he gave there upon mathematical analysis, analytic mechanics, mathematical physics, and, until November 5, 1896, upon celestial mechanics, have been preserved for us, thanks to the initiative of some of his students who, having carefully collected them, published them with his consent. Moreover, from 1904 to 1908 he held the chair of General Astronomy at the Ecole Polytechnique and, from 1902, he was also professor of Theoretical Electricity at the College of Posts and Telegraphy. When POINCARÉ was elected to membership in the Academy of Sciences, January 13, 1887, he had been for several years a member of two royal societies, those of Göttingen and Upsala. He was made a member of twenty-one royal or national societies in foreign countries in addition to a great number of important scientific societies. Eight universities conferred upon him the title of Doctor Honoris Causa. He obtained from France, from Sweden, from England, from America, and from Hungary prizes and gold medals as a reward for the beautiful works which have caused his name to be greatly appreciated and his genius praised. In 1906 he held the office of president of the Academy of Sciences. On March 5, 1908, he was elected to membership in the French Academy in place of SULLY PRUD'HOMME. It was a surprise and a grief to all when we were informed of the sudden death of POINCARÉ on July 17, 1912; we were ignorant of the fact that several days previous he had undergone a difficult surgical operation.

We are under the sad impression that science has lost its most active representative, the most versatile, the keenest, and the most capable to present valuable explanations of difficult and delicate questions.

The space at our disposal permits us to present but briefly some of the investigations of POINCARÉ. His first researches in the theory of numbers, in the theory of differential equations and of analytic functions of one or more variables led to some entirely new results which showed an original and great mind and even as great a richness of invention. Basing his researches upon some propositions due to BRIOT, to BOUQUET and himself, and upon the development in series given by SOPHIE KOWALEVSKI, POINCARÉ found that the family of curves of differential equations of the first order present three kinds of singular points, the cusps, the nodes, and the foci, and he discovered between the curves, which pass through these three kinds of points, a constant relation identical with EULER's theorem upon the number of vertices, faces, and edges of a polyhedron. These researches and others of the same importance upon differential equations of the first order and first degree, upon the integration of linear differential equations, and upon the Θ functions have led POINCARÉ to the most brilliant of his discoveries, that theory of functions which he named Fuchsian in honor of the illustrious FUCHS, whose beautiful works upon linear differential equations of any order whatever had assisted him in his researches. POINCARÉ was then twenty-seven years old. Among the results which he has obtained, it is important to point out that which has given rise to numerous works: the general integral of the linear equation with algebraic coefficients of any order whatever may be obtained by the ζ Fuchsian functions.

But it is of the numerous and important researches of POINCARÉ in celestial mechanics on which I have the task to speak fully in this very brief notice. I will mention first a research in analytic mechanics which relates to the equilibrium of a fluid mass in rotation, because it is of the highest interest in celestial mechanics. We know that JACOBI pointed out the existence of ellipsoids, which have three unequal axes, as well as ellipsoids of revolution which are figures of equilibrium, and, further, that Sir WILLIAM THOMSON (Lord KELVIN) and

TAIT announced the existence of three other figures of equilibrium. Continuing the researches of these scholars, POINCARÉ was led, in 1885, to discover an infinite series of other figures of equilibrium, of which one, slightly different from the ellipsoid of JACOBI, is stable, and of which all the remainder, very little different from the ellipsoid of revolution, are on the contrary unstable.

Many of his researches in celestial mechanics relate to methods in actual practice. For example, he has perfected the method for the approximate development of the perturbative function, so important in the problem of three bodies; he has indicated, for the integration of differential equations by series, a better grouping of the terms of these series in order to obtain a rapid convergence; he has perfected the calculations relating to the equations of motions of the Moon and the perigee of this body; he has expressed his regret that the method of determination of orbits of planets proposed by LAPLACE was abandoned, for it presented certain advantages, of which the principal is the ability to use more than three observations; he has studied the conditions of the stability of the rings of *Saturn*, of the theory of small planets of the *Hecuba* type, and of the satellites of *Jupiter*; he has presented some notes on the calculations relating to the determination of the figure of the Earth, from measures of gravity and from deflections from the vertical.

Other more original researches relate to the problem of the tides, which is so complicated that we have not been able thus far to solve it by taking simultaneously into our calculations the attraction of certain bodies, of the prolate form produced by these bodies, of the presence of continents, and of the rotation of the Earth. We have considered the real oscillations of the sea as being the super-position of a great number of periodical oscillations, of which some are of short period, the others of long period. In 1896 POINCARÉ, by taking account at the same time of the prolate form of the Earth and of the presence of the continents, was led to treat the problem of oscillations of long periods by introducing certain functions which depend upon the form of the continents; then, taking account solely of the presence of continents, he studied the problem of

the short-period oscillations; finally, he has shown that the study of the motion of the sea, taking into account the rotation of the Earth, can be connected with the foregoing researches.

Among his other researches, the most important relate to new methods which it will soon be found necessary to apply to the problem of three bodies. In order to show clearly the importance and the scope of his conception of this subject, it is well to recall, at least briefly, the origin of this important problem. In the problem of three bodies, it is proposed to determine at each instant the mutual distances of the celestial bodies subject to the law of universal gravitation. NEWTON had only approximated the problem by geometric considerations. Thanks to the progress of mathematical analysis made since his time, geometricians have been able, in submitting this problem to computation, to make the determination of the motion of a planet depend upon a system of simultaneous differential equations. As we do not know how to integrate these equations, we are obliged to develop series of formulæ for the motion and to compute the most important terms by a method of approximation. The first developments were made chiefly by LAGRANGE, LAPLACE, and LE VERRIER, who perfected the methods to such a point that we are able to predict for long periods the position which the Sun, Moon, and planets should occupy in the sky. But the series employed contain some secular terms the convergence of which becomes doubtful when the time has a very large value. This defect had also been pointed out by the founders of celestial mechanics. Since the presence of these terms is due solely to the method of development employed, geometricians, notably DELAUNAY, POINCARÉ, NEWCOMB, HILL, GYLDEN, and LINDSTEDT have endeavored to find new methods to overcome the difficulties arising from the secular terms. But the new series are not convergent. We reach the goal proposed by celestial mechanics only after we have first taken into account the degree of approximation of the developments and have recognized whether NEWTON's law is or is not applicable to the explanation of all these phenomena. We are indebted to POINCARÉ for having given methods to obtain the upper limit of the errors

committed in employing such series, which he published in 1889, in a celebrated memoir entitled "Sur les équations de la dynamique et le problème des trois corps," and in 1892 to 1899, with some new ideas, in a masterly work which has the title, "Les Méthodes nouvelles de la Mécanique céleste." It is impossible to cite here the numerous results contained in these valuable papers, which geomericians will long continue to consult; but I believe it necessary to draw attention to two important points: First, POINCARÉ demonstrated entirely rigorously that the problem of three bodies admits of three remarkable particular solutions, which he called periodic, asymptotic, and doubly asymptotic, for each of which the three bodies, at the end of a certain time, will again take the same relative positions; next, he succeeded in proving that the general solution of this problem, if we are ever able to discover it, will require analytic methods which will be more complicated than, and entirely different from, those which we now know.

Mathematician, physicist, astronomer, philosopher, POINCARÉ was an author and a poet as well. He sang of the beauties of nature; not that beauty which "flatters" the senses, the "beauty of qualities and appearances," which he despised, but that "special," deeper beauty "which comes from harmonious order and which a pure intelligence can comprehend." As JULES CLARETIE said at his tomb, HENRI POINCARÉ was "comme un aède de la science, comme un poète de l'infini."